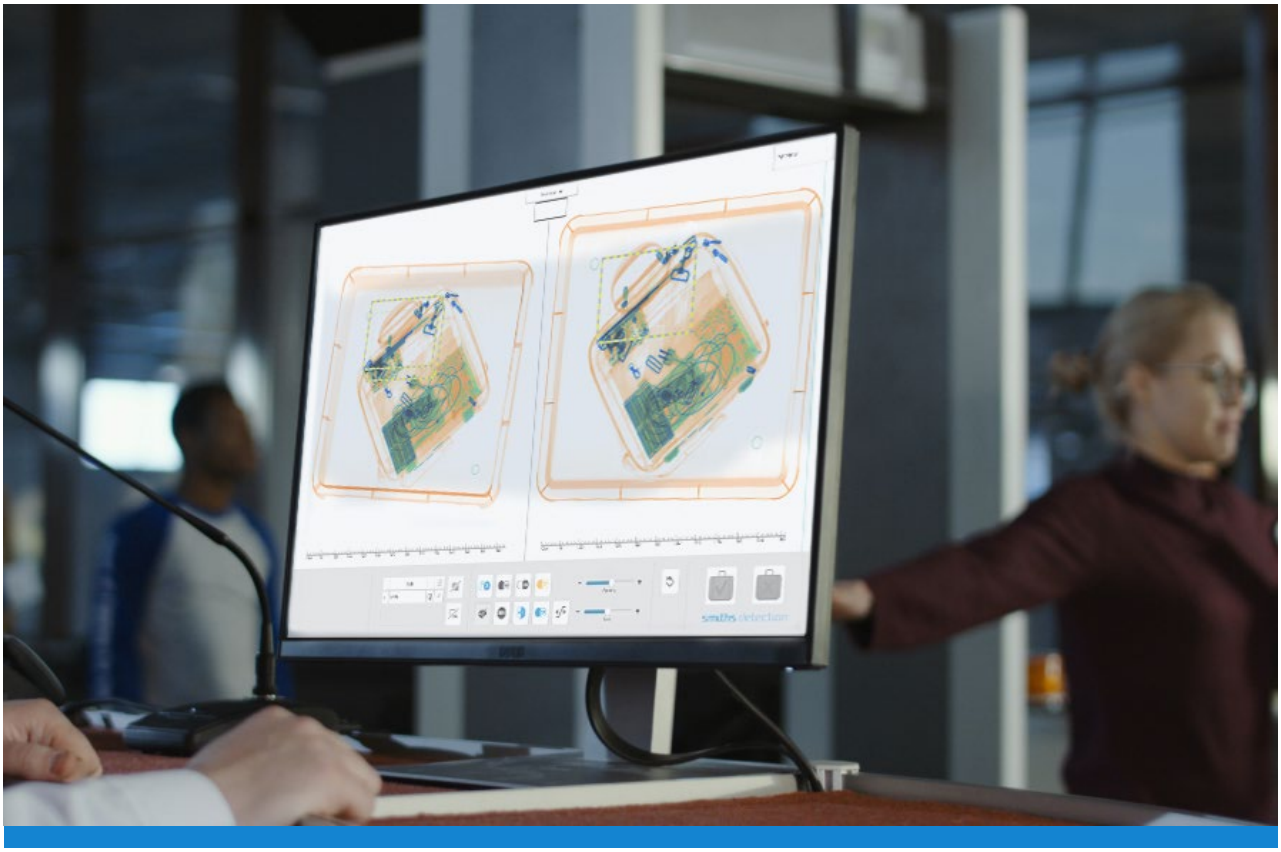
AUTOMATIC OBJECT RECOGNITION IN AVIATION SECURITY

THE ROLE OF ARTIFICAL INTELLIGENCE AND DEEP LEARNING IN SECURITY SCREENING

Dr. Andreas Mader, Head of Department R&D Signal Processing

smiths detection



Artificial intelligence is quickly changing the security landscape. Understanding how to leverage it for an enhanced security operation is the key for tomorrow.

Artificial Intelligence (AI) is everywhere. It pervades daily life in technologies like Netflix and Alexa and enhances many features on our smartphones such as navigation and virtual reality. It is used in insurance claims processing; drug safety analysis; fraud detection; and cognitive robotics to name just a few.

A key factor in AI is machine learning and its subset, deep learning, which supports the development of self-teaching algorithms; imitating the way the human brain processes data and identifying patterns to use in decision-making. The exponential growth in computing power and the sheer amount of available data, make it possible to refine the algorithms needed to deliver truly meaningful insights.

Security screening processes already generate large volumes of data. There is potential for this data to be used in more automated, intelligent ways to improve and optimise machine performance, introduce new capabilities and generate new insights for both screening outcomes and operations. Smart, adaptable deep learning algorithms are now being developed for the automatic detection of an expanding list of dangerous, prohibited and contraband goods and substances. They provide invaluable support for security operators, customs officers and other control authorities.

In this white paper we explore how this accurate, reliable and powerful detection reduces the burden on image analysts. Delivering improved levels of safety, security and efficiency, these algorithms can identify potential threats and help combat the movement of unsafe, undeclared or illegal goods.

SECURITY, SAFETY, SMUGGLING

Detecting prohibited items at the security checkpoint

Automatic detection algorithms already deliver highly accurate automatic detection of guns, gun parts, ammunition and knives, improving security levels and efficiency at checkpoints.

These detection capabilities support image analysts and are particularly helpful for less experienced operators. As algorithms do not tire or get distracted and are impartial, they reduce the risk of human errors.

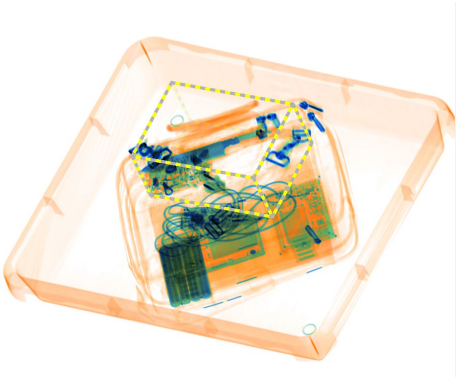
With the list of prohibited items detected expanding to include, for example, sharp and blunt objects, these algorithms can facilitate a more automated screening process in the future. Especially when combined with automatic explosives detection and risk-based screening approaches, they can enable "alarm-only viewing" of X-ray images at checkpoints, (a concept which has been in use for hold baggage screening at airports for several years). In addition to increasing security levels, this would also reduce operational expenditure and improve throughput.

Acknowledging the huge potential of more automated screening concepts at the checkpoint, aviation security regulators in several countries are already working towards the implementation of standard certification and test methods for object recognition capabilities.

Mitigating the safety risk posed by dangerous goods

Lithium batteries and other dangerous goods detection algorithms have been developed to mitigate the risk posed by undeclared goods in support of the IATA recommendations on the shipping of Dangerous Goods.

The potential that lithium batteries ignite is a real threat to the aviation industry, particularly where the batteries are either low quality or counterfeit.

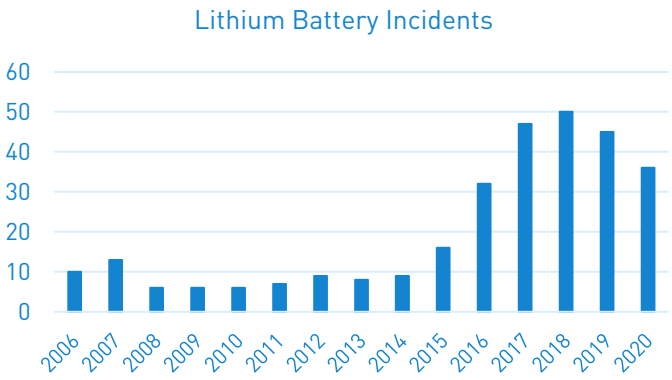


Automatic detection of a concealed knife using iCMORE Weapons on a HI-SCAN 6040 CTiX

Alarm-only viewing at checkpoints - using operators only for alarm resolution - provides numerous benefits

- Increased security
- Reduced costs
- Improved throughput

As of 4 November 2020, the United States Department for Administration, Federal Aviation Administration has recorded 300 air/airport incidents since January 2006 involving lithium batteries carried as cargo or baggage, with a significant jump in incidents occurring since 2016*.



Preventing smuggling and trade in illicit goods and endangered species

Customs authorities would also greatly benefit from the automatic detection of currencies, endangered species, agriculture products and other contraband in baggage or freight to stop the illegal entry of these items into their countries and developers are busy making this a reality.

There are without doubt benefits to be gained by sharing information on detected objects between airports, countries and authorities using wide area networks. For example, X-ray images captured at a departure airport could be sent securely to the transfer and/or destination airport for review by local Customs, Security, Agriculture or other control authorities while the plane is in the air.

*United States Department for Administration, Federal Aviation Administration: Events with Smoke, Fire, Extreme Heat, Or Explosion Involving Lithium Batteries

iCMORE Dangerous Goods automatically detects lithium batteries, liquified & compressed gases as well as flammable liquids & solid

"The global trade in endangered species, over 1.5 million transactions per year, will drive some species to extinction if the trade is not stopped."

Border Security Report

smiths detection

BEYOND SCANNING

Looking beyond image interpretation applications, there are many potential use cases for artificial intelligence in aviation security, such as behavioural or scene analysis techniques, the identification of patterns in the spectra of trace explosives and the use in biometrics. Let's have a closer look at two particularly compelling examples, risk assessment and predictive analytics.

Risk assessment support

AI could also be used to combine and analyse comprehensive passenger risk profiles, including for example: travel, passport, visa and biometric data as well as flight behaviour patterns and critical government and security services intelligence from criminal records, "person of interest" files and other relevant sources. The same principle could be applied to freight, analysing shipper and consignee data, manifest contents etc.

Prediction of critical operational conditions

Using AI algorithms for asset performance management and predictive maintenance can have a major impact on the performance, reliability and uptime of screening equipment. They are able to take large amounts of data and turn it into actionable, predictive service and performance insights. Using the latest in sensors and data analytics technology, airport operations teams can monitor machine condition and overall performance of their entire installed base of screening equipment.

Asset Performance Management

Specialist Asset Performance Management (APM) application suites are data driven and designed to improve reliability and availability whilst minimising risk and operating costs. With data to hand on asset history, current health and how to mitigate the risk of failure, it is possible to manage maintenance and move towards zero unexpected failures.

THE SCIENCE BEHIND AUTOMATIC OBJECT RECOGNITION

There are two possible algorithmic approaches to automatic object recognition – and combinations of both:

- Machine learning – Deep learning
- Material discrimination-based image processing

Which approach offers the greatest benefits depends largely on the items to be detected.

Deep learning object recognition

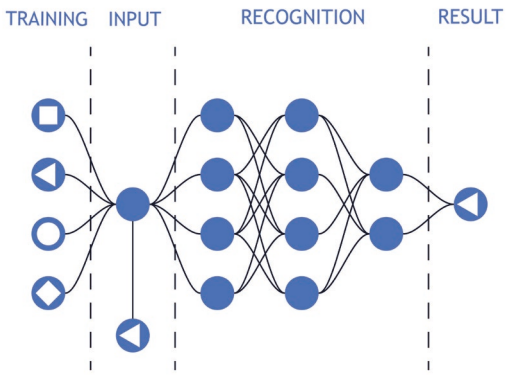
At its most basic, deep learning is where an algorithm is "taught" to recognise patterns based on examples. It is inspired by the structure and function of the human brain, which is made up of networked neurons. Just like the human brain, the network must be trained. The simplest form of training is to provide examples.

For the development of its deep learning algorithms Smiths Detection partnered with customers and authorities to obtain thousands of X-ray images. After labelling the to-be-detected objects in these X-ray images, they were "fed" to the algorithm so that it could learn to identify patterns in the shape of items such as weapons or lithium batteries.

This way algorithms can be taught to recognise anything with identifiable characteristics. However, deep learning has its limitations and is not yet reliable enough for detecting substances such as drugs or explosives which are often inconsistent in shape or form. In these cases, classical material discrimination techniques are still effective and when combined with machine learning even more powerful.

Material discrimination-based image processing

When items need to be detected by discriminating their material, rather than their shape, classical image processing segments and classifies objects based on their X-ray absorption characteristics. This approach uses machine learning algorithms as well to identify objects. In this case they are however trained to recognise patterns in material properties, rather than shape.



Deep learning is all about 'training' an algorithm to automatically recognise patterns and shapes based on many given examples.

IT'S ABOUT COLLABORATION

High-performant neural networks are nowadays readily available and have opened the doors to many new companies to enter the market.

However, in order to develop advanced object recognition algorithms, which can be integrated seamlessly into workflows without compromising compliance or operational efficiency, close cooperation between all suppliers, airports and authorities is important.

Access to a large variety of raw data

Access to the raw image data is a general advantage when developing algorithms. As mentioned before, in order to identify an object, which does not have a consistent and characteristic shape, using raw data for classical material discrimination methods is the only option. Since these traditional algorithms require long-lasting domain experience, third party developers are usually limited to deep learning algorithms using less rich data, if they do not cooperate with an Original Equipment Manufacturer (OEM) on the development.

In contrast to traditional algorithms, deep learning-based algorithms learn from the images they are being fed. A high variety of data collected from different airports and countries improves the detection performance. Government bodies and airports, who often own the X-ray images, need to work closely with security solutions providers to share this data. In addition, for those threats, which cannot be found in field data, specific data-collection sessions need be organised with authorities or test institutes (e.g., firearms).

Certification, workflows and integration

The integration of automatic object recognition into screening workflows without impacting the speed of the image evaluation, putting any operational functions or certifications at risk is crucial. When considering to work with third party algorithm developers, be sure to consult with your OEM from the beginning to ensure this can be achieved to the satisfaction of all parties.

Experience & partnering

In addition to over 20 years of experience in developing certified explosives detection algorithms, Smiths Detection have also been leveraging machine learning for more than 15 years.

We are proactively working with multiple regulators, governments and airports all over the world on the development of iCMORE object recognition applications for Aviation, Ports & Borders as well as Urban Security applications.

Collaborating with third party companies and universities such as Duke University, TU Darmstadt, National University of Singapore and Nanyang Technological University (Singapore) is central to our ongoing innovation approach.

Comparing performance

Comparing performance data of automatic detection algorithms is not straightforward, as there are no common test methods yet. Often, quoted detection rates are based on very simple test sets or on objects which have been used for both training and testing of the algorithms. The rates achieved in the field or when using different test objects can differ significantly.

WHAT DOES THE FUTURE HOLD

The most obvious way forward with regards to automatic object recognition is to add further dangerous goods, prohibited items and other objects to the target recognition list.

While current algorithms are based on 2D images (even if run on CT systems), the development of true volumetric object detection will be a game changer with the growing use of CT based systems for cabin baggage, hold baggage and freight. Read more on Smiths Detections work in this area here.

In order to fully realise the huge potential of these capabilities and enable alarm-only viewing at the checkpoint as well as the transfer of images across airports and countries, the definition of standards, common test and certification methods will be critical.

Open architecture approaches that enable the sharing of image data and the integration of third-party algorithms can certainly pave the way to a more secure airport network if, and only if, the industry pulls together a common framework to ensure open architecture platforms operate safely and compliantly. Image analysis and distribution are critical, regulated and often classified functions and should never be compromised.

The way forward is increased collaboration and constructive engagement not only between suppliers, but between suppliers, airports and regulators. Only through working more closely together will the industry realise the opportunity for a more integrated, data-driven and ultimately secure future.

GET IN TOUCH

If you would like to know more about checkpoint management systems and how we help make the world a safer place, you can get in touch at;

Email address: aviation-solutions@smithsdetection.com

www.smithsdetection.com